

Extremely Low-Frequency (ELF) Magnetic Field (MF) Exposures and Cancer Risks

**Martha S. Linet, M.D.
Radiation Epidemiology Branch
Division of Cancer Epidemiology & Genetics
National Cancer Institute**

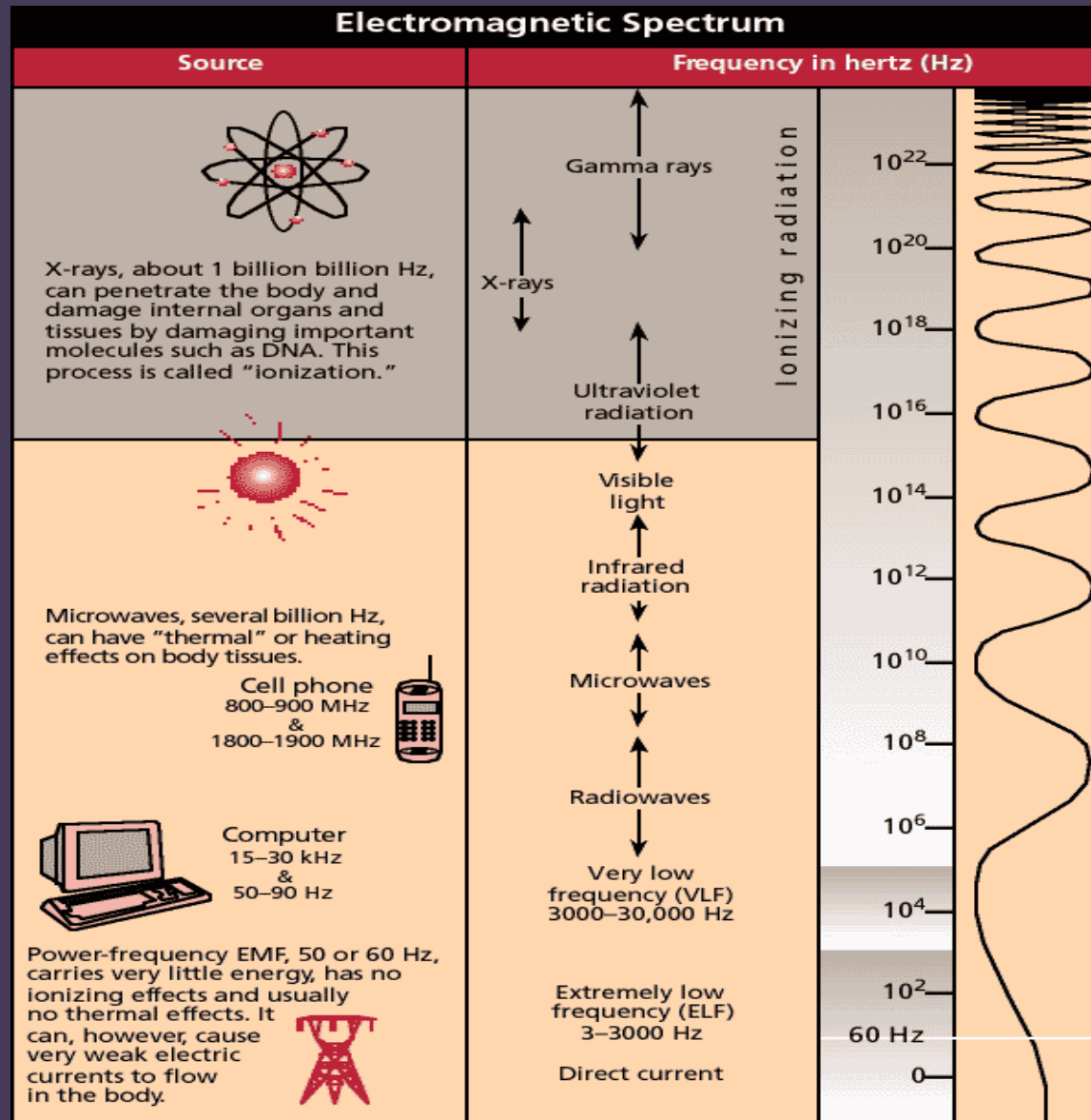
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Outline

- I. Background & Terminology
- II. Extremely low frequency (ELF) (power frequency) magnetic field (MF) exposure measurements
- III. ELF MF exposures and cancer risks

Background and Terminology

Electromagnetic Spectrum



Terminology - 1

- **Electromagnetic spectrum**
 - > Frequency: cycles per second (Hertz)
 - > 1 cycle = 1 wavelength
 - > as frequency \uparrow , wavelength \downarrow
- **Electric fields**
 - > measured in volts per meter
 - > easily shielded
- **Magnetic fields (MF)**
 - > measured in gauss (G) or tesla (T)
 - > not easily shielded

Electric vs. Magnetic Fields

A Comparison of Electric and Magnetic Fields

Electric Fields

- Produced by **voltage**.

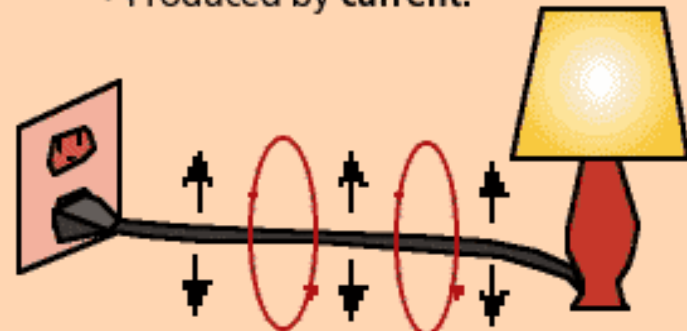


Lamp plugged in but turned off.
Voltage produces an electric field.

- Measured in **volts per meter (V/m)** or in **kilovolts per meter (kV/m)**.
- **Easily shielded** (weakened) by conducting objects such as trees and buildings.
- Strength decreases rapidly with increasing distance from the source.

Magnetic Fields

- Produced by **current**.



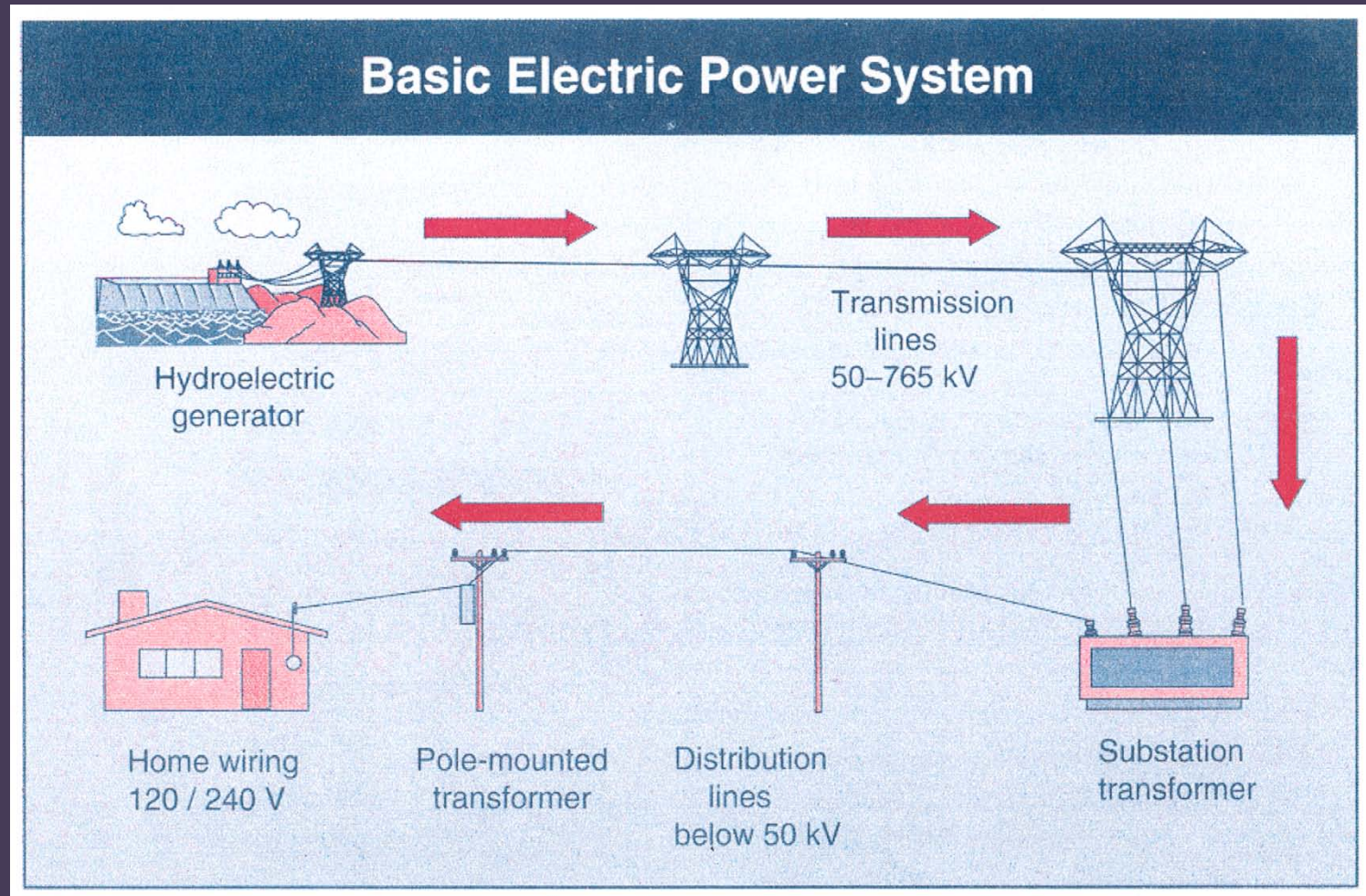
Lamp plugged in and turned on. Current now produces a magnetic field also.

- Measured in **gauss (G)** or **tesla (T)**.
- **Not easily shielded** (weakened) by most material.
- Strength decreases rapidly with increasing distance from the source.

Terminology - 2

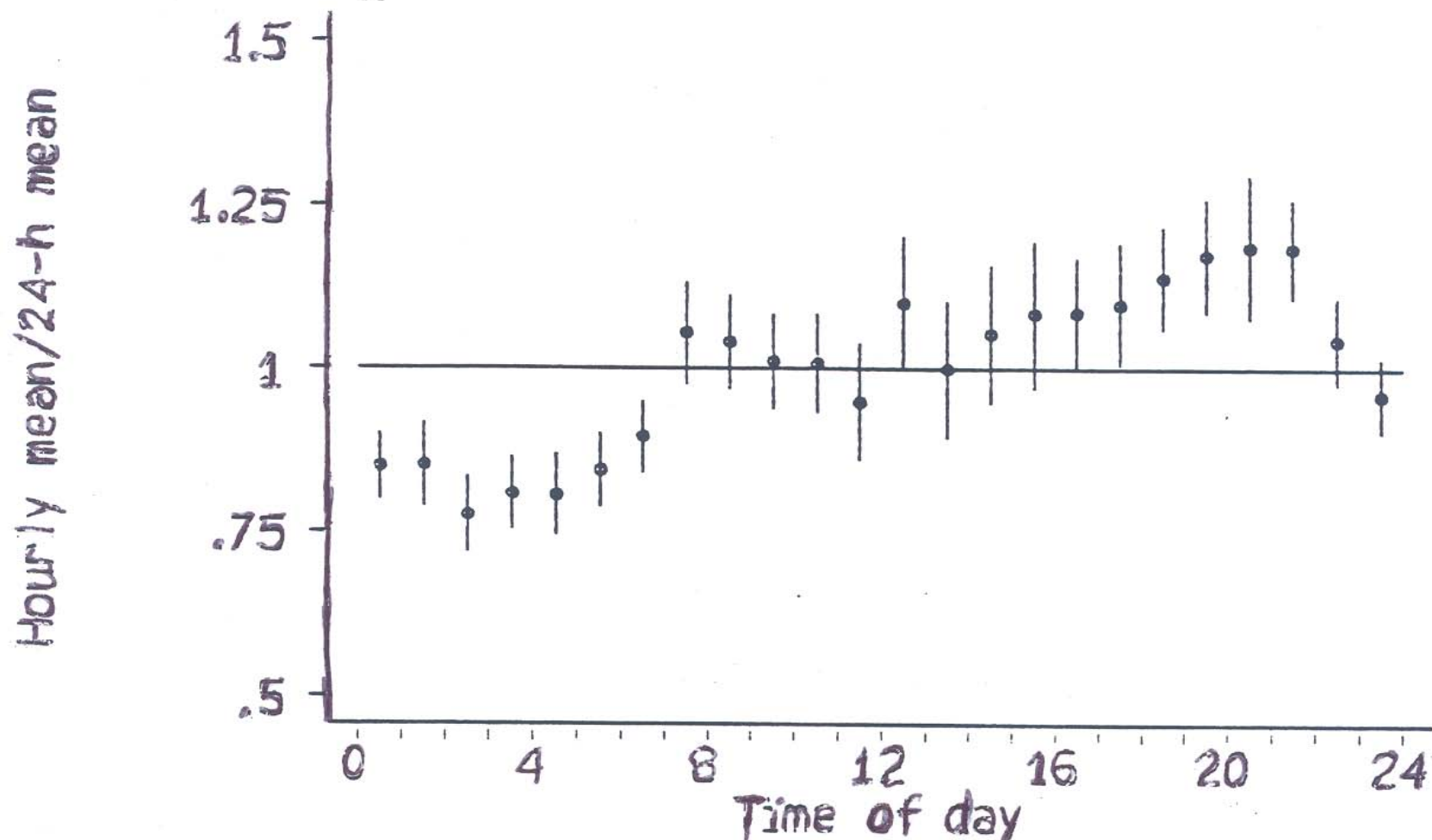
- **Current = movement of electric charge**
 - > AC = electric power 'alternates' at 60 Hz (50 Hz) inducing weak currents in humans
 - > DC = 'direct current' flows from batteries to appliance (doesn't induce currents)
- **Voltage = potential to do work**
- **Power = product of volts and currents**
- **Conductor = material that carries current**
- **Load = electric power needed by homes, businesses, schools, etc.**

Electric Power: From Power Plant to Home

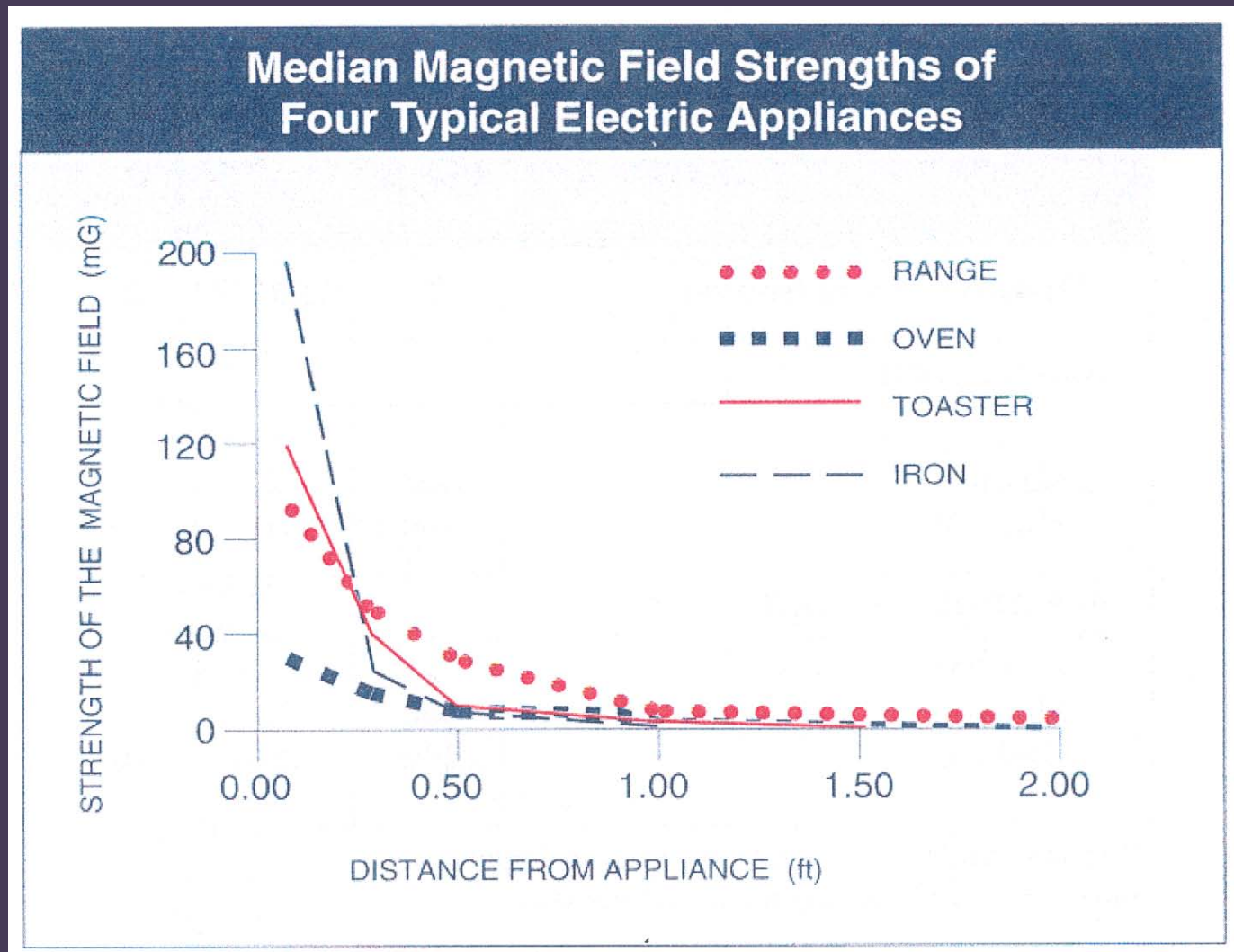


**Extremely low frequency (ELF)
magnetic field (MF)
exposure assessment**

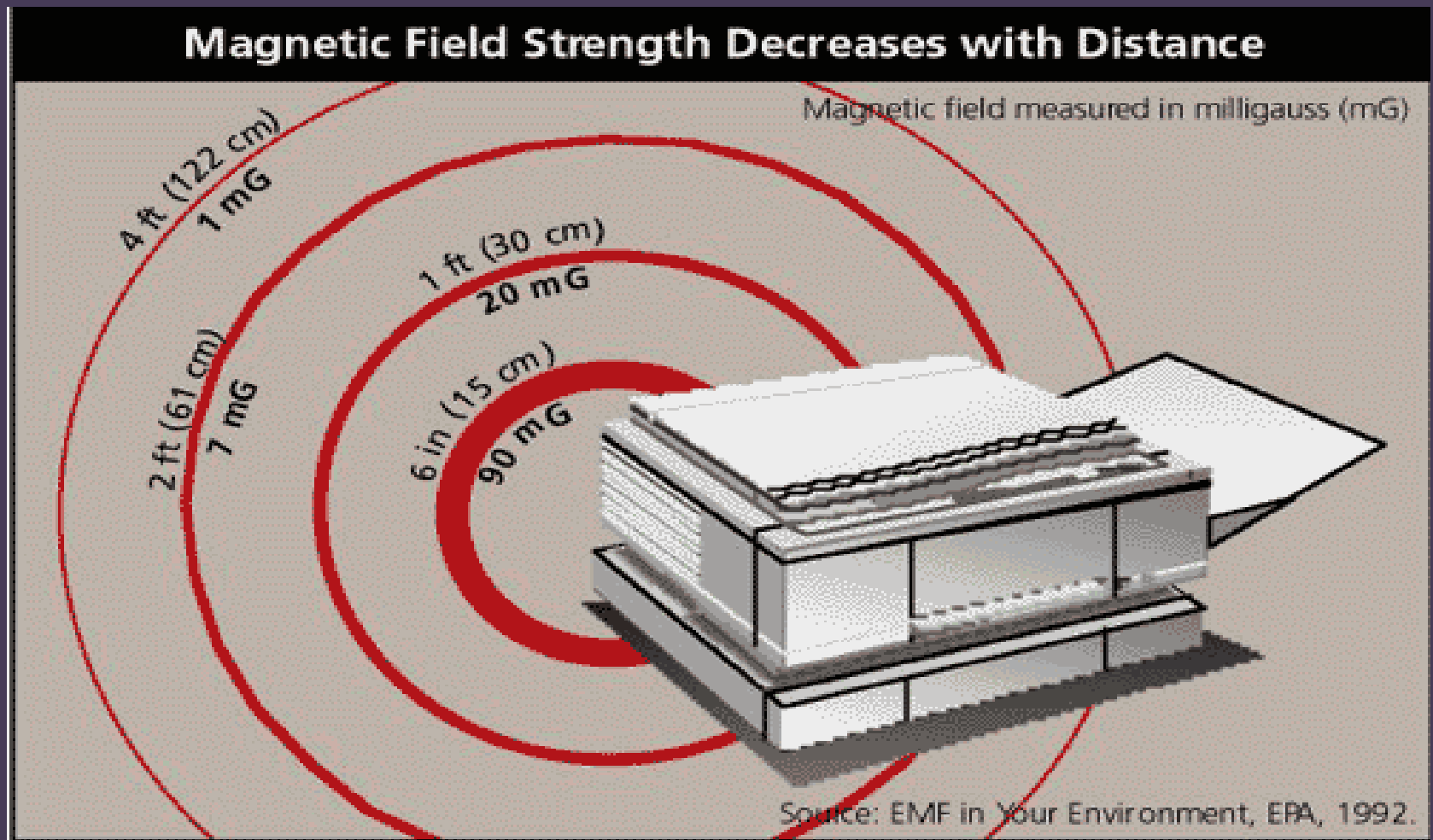
ELF MF in Homes: 24 Hr Measurements



Dramatic ELF MF Decline at Short Distances



↑ Distance from Source → ↓ MF Levels



Types of ELF MF Measurements - 1

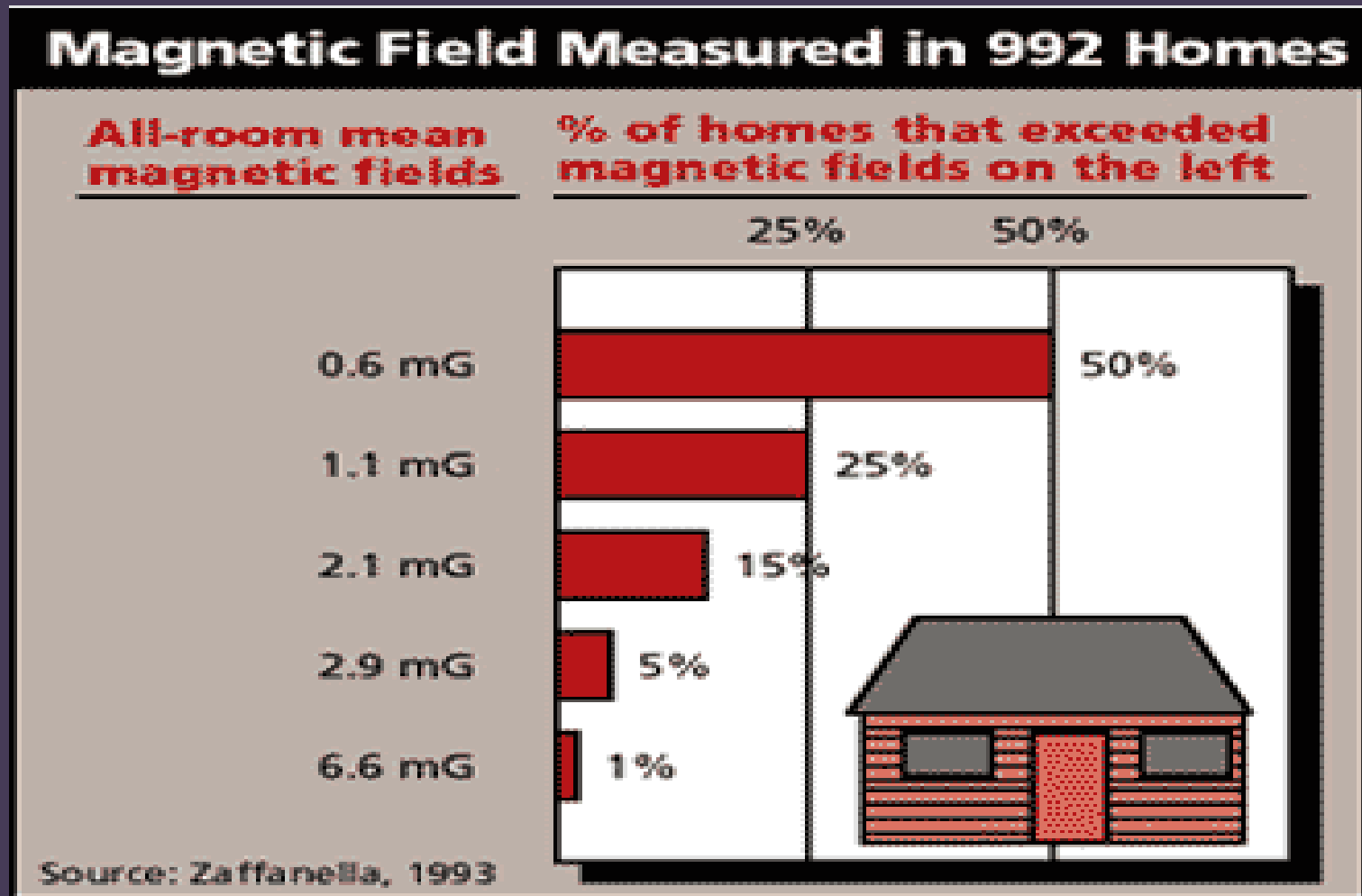
- **Direct measures**

- > reported in milligauss (mG) or microtesla (μT):
1 mG = 0.1 μT
- > “spot” (30-second) measurements
- > 24-hour measurements

- **Personal monitoring**

- > residential
- > school
- > job

Summary of ELF MF Levels in Homes



Types of ELF MF Measurements - 2

- **Proxy measures**

- > **wire codes: based on power line distance, thickness, configuration**
- > **historical estimated exposures: transmission line distance & load**
- > **distance of residence from transmission lines**

ELF MF Exposure And Cancer Risk

Childhood Cancer Residential Studies: Summary

- 1979 - Wertheimer-Leeper
- 17 subsequent studies
 - 9 several types of cancer
 - 7 leukemia only
 - 2 brain only
- Study size increased over time
- Some variation in types of measurements
- Exposure assessment improved

Childhood Cancer Residential Studies: Temporal Changes in Exposure Assessment

- Early studies (Denver): wire codes (1979, 1988) or spot measurements (1988)
- Scandinavian studies (1993-97): historical estimated levels from registry data
- North American, German, UK, Australian, Japanese: direct measurements

Childhood Cancer Residential Studies: Results - 1

- **By threshold level**
 - > focus on wire code level in earlier studies
 - > focus shifted from $>0.2 \mu\text{T}$ to $>0.3 \mu\text{T}$ and finally $>0.4 \mu\text{T}$ in later studies
- **By metric or time of day**
 - > most studies: time-weighted average
 - > German study: median and night-time risks
 - > NCI study: explored alternative metrics (but central tendency showed highest risks)

Childhood Cancer Residential Studies: Results - 2

- **Ahlbom et al, 2000**

- > Combined 9 well-conducted studies
- > No childhood leukemia risk increase at/below 0.4 μT MF exposure; two-fold excess risk associated with MF exposure $>0.4 \mu\text{T}$

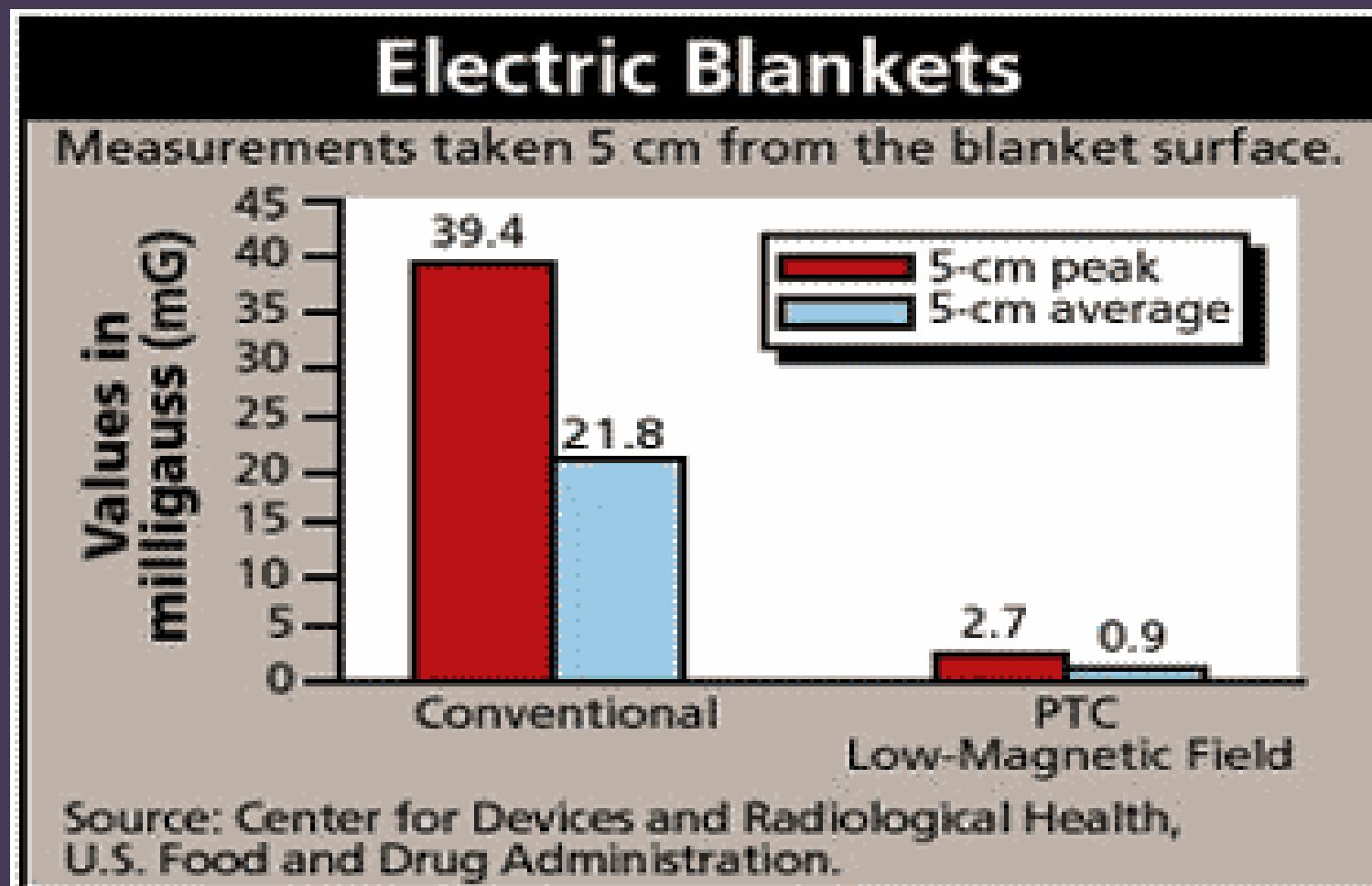
- **Greenland et al, 2000**

- > Combined 15 studies
- > No childhood leukemia risk increase at/below 0.3 μT ; two-fold excess risk at MF levels $>0.3 \mu\text{T}$

Childhood Cancer Appliance Studies: Results

- **5 studies: all interviewed mothers to assess prenatal and postnatal exposure information**
 - **leukemia (4 studies)**
 - > risks: use of prenatal (2 studies) & postnatal (3) electric blankets, hair dryers (2), TV watching (2)
 - > no consistent dose-response
 - > TV linked with duration, not distance
 - > MF measured levels at typical distances not greater than ambient MF levels
 - **brain (3 studies)**
 - > little consistency among results

MF Levels: Old Vs. New Electrical Blankets



Adult Cancer Residential Studies: Results

- 4 leukemia studies

- > all studied exposures from transmission lines
- > no association for 3, small ↑ risk for 1

- 4 brain tumor studies

- > all studied exposures from transmission lines
- > none showed evidence of an association

- 9 breast cancer studies

- > direct measurements (3), wire codes (4), and distance from transmission lines (5)
- > no association for 8; small ↑ for 1 (subgroups)

Adult Occupational Studies: Results - 1

■ Leukemia studies

- > **job title** meta-analysis: RR = 1.2 all leukemia, RR = 1.4 CLL workers in electrical occupations
- > **job measurements**: ↑ risks in 5/10, RR = 1.5 – 2.5, ↑ AML in 2, ↑ CLL in 2

■ Brain tumor studies

- > **job title** meta-analysis: RR = 1.2 total brain, RR = 1.4 gliomas for workers in electrical occupations, RR = 1.7 in electrical engineers
- > **job measurements**: ↑ risks in 5/10, RR = 1.3 – 3.1, little evaluation of brain tumor subtypes

Adult Occupational Studies: Results - 2

■ Male breast cancer

- > **5 case-control studies**: 2 significantly ↑ risks (OR = 1.8, 2.2)
- > **14 cohort studies**: some limited in power, 2 significantly ↑ risks (RR = 2.1, 4.9)

■ Female breast cancer

- > **6 case-control studies**: 2 significantly ↑ risks (PMA=1.38; OR=1.14 whites, OR=1.34 blacks)
- > **10 cohort studies**: 1 significantly ↑ risks (RR = 1.14)

Outcomes Other than Cancer

- Limited data on outcomes other than cancer, results not clear or consistent
 - neurodegenerative diseases
 - > amyotrophic lateral sclerosis
 - > Alzheimer's disease
 - suicide and depression
 - reproductive disorders
 - > spontaneous abortion
 - > low birth weight
 - > congenital malformations
 - cardiac effects
 - > heart rate
 - > cardiovascular disease mortality

Experimental Data

- Voluminous literature, no replication of positive studies (Portier and Wolfe (eds) NIH Publ No. 98-3981, Research Triangle Park, NC, NIEHS, 1998)
- Large, well-controlled studies all null (Boorman GA et al. 1997, 1999, 2000a, b; McCormick et al. 1999)

Summary ELF MF Exposures

Power lines & childhood leukemia: no association below 0.4 μT , risk \uparrow 2-fold at $\geq 0.4 \mu\text{T}$; no experimental support

Power lines & other childhood or adult cancers: no evidence of associations

Electrical appliances and cancer risk: little evidence supporting associations with childhood or adult cancers

Occupational exposures: modest increases of leukemia & brain tumors in some studies of electrical workers

Experimental studies: no evidence of cancer risks